**EXPLANATION** 

See table at right for description

of geologic units

FAULT-U, Upthrown side:

T. 37 N.

T. 36 N.

DISSOLVED-SOLIDS CONCENTRATION, IN MILLIGRAMS PER LITRE

Little or no information available

Less than 500

Greater than 1000

---- CONTACT

Hydrologic characteristics

quality is variable, depending on under-

lying rock and source of alluvial mater Dissolved-solids concentration

ranges from 137 to 360 mg/1. Alluvium is absent or thin in the Animas River valley south of Durango. One well sampled contained fluoride in concentration above U.S. Public Health Service (1962)

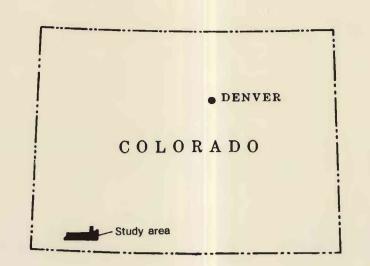
Saturated only in lower part; not a known

aquifer in the Durango area. Transmits

standards for drinking water.

water to underlying aquifers.

Reported well yields are as much as 25 gal/min, but average 15 gal/min. Wate



### INTRODUCTION

This report presents the results of an investigation of the ground-water resources of the central part of La Plata County, Colo. The investigation was begun in 1974 by the U.S. Geological Survey in cooperation with the Colorado Division of Water Resources, Office of the State

The purpose of the investigation was to describe the geologic units and the availability and quality of ground water in the central part of the county. Parts of the county had undergone rapid population growth in recent years. This rapid growth has resulted in an increased demand for additional domestic, industrial, and municipal water supplies. A knowledge of the occurrence and quality of ground water will permit a more efficient allocation of the resource.

The investigation included identification of aquifer units and determination of hydrologic characteristics of the aquifers. This was accomplished by reviewing published geologic maps and reports, obtaining data from existing wells, and conducting aquifer tests on selected wells throughout the study area. Samples of water were collected from wells and springs and analyzed to define the chemical quality of water in the aguifers. Geologic information used in the preparation of this report is published in reports by Steven, Lipman, Hail, Barker, and Luedke (1974); Haynes, Vogel, and Wyant (1972); and Zapp (1949). Basic hydrologic data presented in this report were collected during the fall and winter of 1974 and the spring of 1975. Robert E. Lauth, Durango, Colo., provided information on the locations of wells completed in certain

#### AVAILABILITY OF GROUND WATER

Rock types in the central part of the county include sandstone, siltstone, shale, and unconsolidated deposits. Unconsolidated deposits are mostly clay, silt, sand, gravel, and boulders (geologic map and table describing geologic units). Ground-water supplies are available from all rock types.

Aquifers in the alluvium are valley-fill sands and gravels that are located in the present-day stream valleys. The alluvial aquifers are thickest, as much as 30 ft (10 m), in the Animas River valley north of Durango. South of Durango, the deposits are absent or are less than 10 ft (3 m) thick. Alluvial aguifers in the La Plata, Florida, and Los Pinos River valleys are generally less than 20 ft (6 m) thick. Ground-water discharge from these aquifers supports base flow in the streams. Yields from wells completed in the alluvial aquifers are generally less than 25 gal/min (1.5 l/s) because of low permeability and limited saturated thickness (hydrologic map).

Aquifers in the alluvium are recharged by leakage from streams through alluvial fans on the flood plains, infiltration from precipitation, and leakage from irrigation ditches that traverse the flood plains and terraces. In the Florida River valley, the aquifers are also recharged by the flow of springs from an aquifer in the Animas Formation.

Terrace deposits are saturated only in their lower part and do not contribute significant quantities of water to wells. Wells are generally drilled through the terrace deposits and completed in the underlying bedrock aguifer to obtain greater supplies of water.

The water-yielding capabilities of bedrock aquifers vary widely and are largely dependent on fracture porosity and permeability. Most reported well yields in the Durango area range from less than 1 gal/min (0.06 l/s) in the hard shales and sandstones to 10 gal/min (0.6 l/s) in fractured shales and sandstones (hydrologic map); although a few isolated wells are reported to yield as much as 50 gal/min (3.1 l/s).

Ground-water circulation patterns in bedrock aquifers are controlled partly by the characteristics of the individual rock unit and partly by the regional geologic structure. Bedrock in the study area dips to the south. Ground water moves downdip and is discharged in New Mexico, probably to the San Juan River and its tributaries. Recharge to the aquifers occurs by infiltration from precipitation and leakage from streambeds where alluvial aquifers in the stream valleys are in hydraulic connection with bedrock aquifers. Near where the aquifers crop out, ground water occurs under water-table conditions; further to the south, the aquifers occur at depth, and ground water is under artesian conditions. In places, the pressure is great enough for ground water to flow to the surface through cased wells.

## CHEMICAL CHARACTERISTICS OF GROUND WATER

Chemical characteristics of ground water vary considerably depending on rock type (water-quality table). There are two types of water in the area: calcium bicarbonate and sodium bicarbonate. Quality of ground water in the alluvial aquifers depends primarily on the characteristics of the alluvium, and varies from a sodium bicarbonate type to a calcium bicarbonate type. Water from these aquifers generally contains less than 400 mg/l (milligrams per litre) dissolved solids.

The quality of ground water stored in the bedrock aquifers also varies from a sodium bicarbonate type to a calcium bicarbonate type. Water from aquifers in the shales is a sodium bicarbonate type, whereas water from aquifers in the sandstones is either a sodium bicarbonate or a calcium bicarbonate type depending on the presence or absence of interbedded shales. The quality of water in the Animas Formation is uniform; of seven water samples analyzed, the concentration of dissolved solids ranges from 309 to 455 mg/l. The analyses show that fluoride is the only constituent that occurs in excess of U.S. Public Health Service (1962) drinking-water standards, and this was found to occur in only

one well. The quality of water in the Mancos Shale is variable; the concentration of dissolved solids ranges from 490 to 4,820 mg/l. Several constituents, including dissolved solids, sulfate, chloride, fluoride, and manganese, can occur in concentrations in excess of those recommended by the U.S. Public Health Service (1962) drinking-water standards. The quality of water in aquifers in the Menefee Formation and Point Lookout Sandstone is influenced by the presence of coal beds in the Menefee Formation. Movement of water through the coals contributes to the high concentrations of iron, manganese,

T. 34 N

Base from U.S. Geological Survey 1:250 000, Cortez, 1962 and

Base from U.S. Geological Survey 1:250 000. Cortez, 1962 and Durango, 1966

## SELECTED REFERENCES

and sulfate in the aquifers. The percolation of

Concentrations of dissolved solids of water from

the Dakota Sandstone range from 273 to 440 mg/1.

water through coal beds in the Dakota Sandstone

also contributes to the high concentrations of

iron and manganese in water in the sandstone.

Atwood, W. W., and Mather, K. F., 1932, Physiography and Quaternary geology of the San Juan Mountains, Colorado: U.S. Geol. Survey Prof. Paper 166, 176 p.

Burbank, W. S., Lovering, T. S., Goddard, E. N., and Eckel, E. B., compilers, 1935, Geologic map of Colorado: U.S. Geol. Survey map, scale 1:500,000 [repr. 1967]. Ekren, E. B., and Houser, F. N., 1959, Prelim-

inary geologic map of the Cortez SW quadrangle, Montezuma County, Colorado: U.S. Geol. Survey Inv. Field Studies Map MF-217, scale 1:24,000.

1965, Geology and petrology of the Ute Mountains area, Colorado: U.S. Geol. Survey Prof. Paper 481, 74 p. Fassett, J. E., 1964, Subsurface geology of the upper Cretaceous Kirtland and Fruitland Formations of the San Juan Basin, New Mexico and Colorado: U.S. Geol. Survey open-

INDEX TO GEOLOGIC MAPPING

2. Steven, Lipman, Hail, Barker, and Luedke, 1974

1. Haynes, Vogel, and Wyant, 1972

• 7 DOMESTIC OR STOCK WELL-Upper number

SPRING-Upper number refers to chemical analysis in water-quality table

ARTESIAN WELL-Upper number refers to

hemical analysis in water-quality table

refers to chemical analysis in water-quality table. Lower number is depth to water below land surface, in feet (to obtain metres multiply

file map, scale 1:250,000. Fassett, J. E., and Hinds, J. S., 1971, Geology and fuel resources of the Fruitland Formation and Kirtland Shale of the San Juan Basin, New Mexico and Colorado: U.S. Geol. Survey Prof. Paper 676, 76 p.

Haynes, D. D., Vogel, J. D., and Wyant, D. G.,

1972, Geology, structure, and uranium deposits of the Cortez quadrangle, Colorado and Utah: U.S. Geol. Survey Misc. Geol. Inv. Map 1-629, scale 1:250,000. Irwin, J. H., 1966, Geology and availability of ground water on the Ute Mountain Indian Reservation, Colorado and New Mexico: U.S.

Geol. Survey Water-Supply Paper 1576-G. 109 p. Larsen, E. S., and Cross, Whitman, 1956, Geology and petrology of the San Juan region, southwestern Colorado: U.S. Geol. Survey Prof. Paper 258, 303 p.

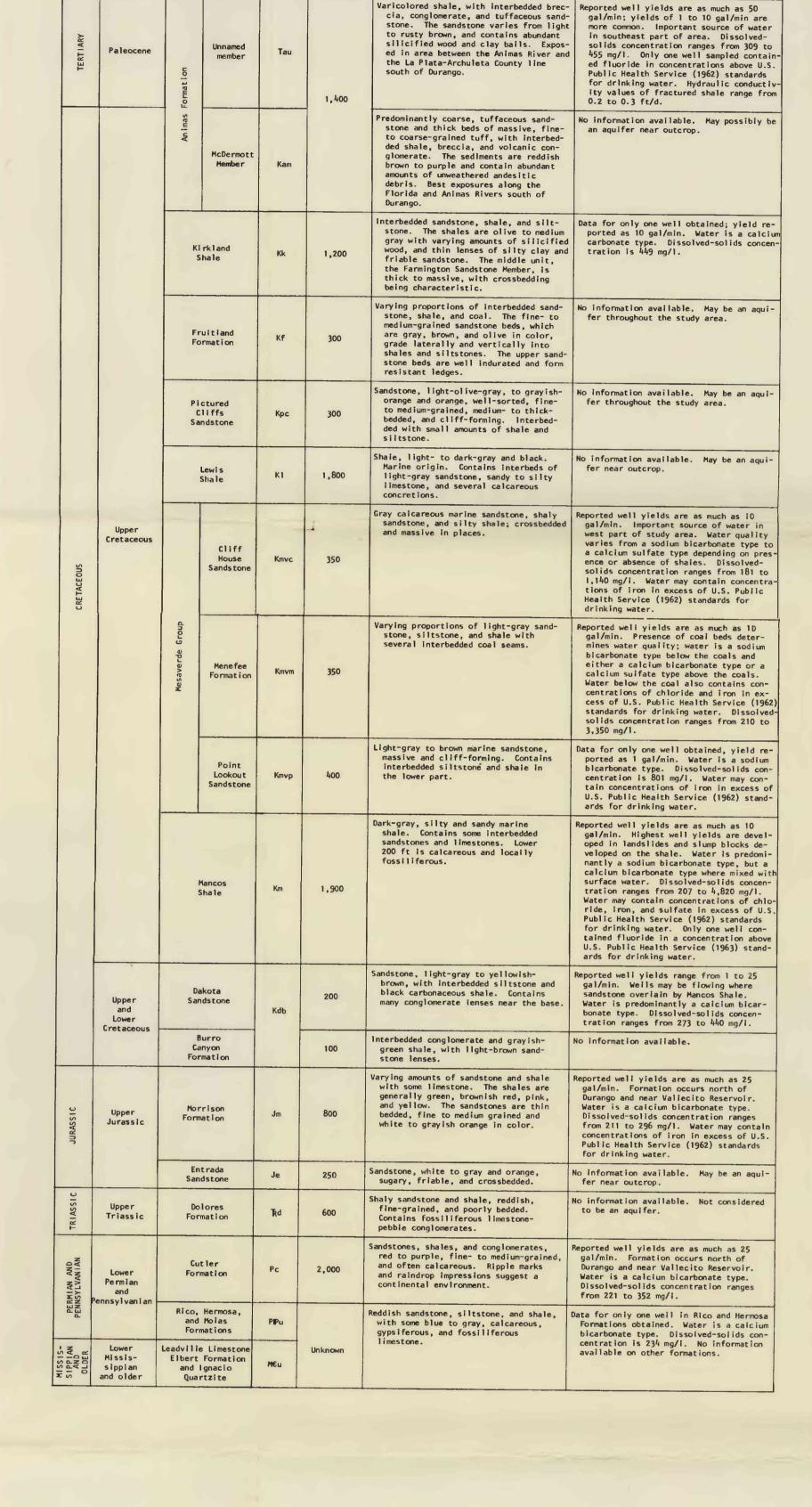
Reeside, J. B., Jr., 1924, Upper Cretaceous and

Tertiary Formations of the western part of the San Juan Basin, Colorado and New Mexico: U.S. Geol. Survey Prof. Paper 134, 70 p. Shomaker, J. W., and Holt, R. D., 1973, Coal resources of Southern Ute and Ute Mountain Ute Indian Reservations, Colorado and New Mexico: Socorro, New Mexico Bur. Mines and Mineral Resources Circ. 134, 22 p.

Steven, T. A., Lipman, P. W., Hail, W. J., Jr., Barker, Fred, and Luedke, R. G., 1974, Geology of the Durango quadrangle, Colorado: U.S. Geol. Survey Misc. Inv. Map 1-764, scale 1:250,000.

U.S. Public Health Service, 1962, Drinking water standards, 1962: U.S. Public Health Service Pub. 956, 61 p. Zapp, A. D., 1949, Geology and coal resources of the Durango area, La Plata and Montezuma

For those readers who may prefer to use metare listed below:



Description of geologic units and their hydrologic properties

Holocene

Alluvium

Physical characteristics

lay, siit, sand, gravel, and boulders.

Clay, silt, sand, gravel, and boulders.

coarser materials being well rounded.

Remnants of aliuvial fans and higher

Sediments are poorly sorted with

level stream valleys.

to present-day stream valleys.

# HYDROLOGIC MAP

2 0 2 4 6 8 KILOMETRES

GEOLOGIC MAP

WELL YIELD, IN GALLONS PER MINUTE (LITRES PER SECOND)

EXPLANATION

1-10 (0.06-0.6)

1-25 (0.06-1.6)

Little or no information available

Counties, Colorado: U.S. Geol. Survey Oil and Gas Inv. Map 109, scale 1:31,680. CONVERSION FACTORS ric units rather than English units, the conversion factors for the terms used in this report

To obtain English unit metric unit feet (ft) 0.3048 metres (m) miles (mi) 1.609 kilometres (km) feet per day (ft/d) .3048 metres per day (m/d) .06309 litres per second gallons per minute (gal/min) (1/s)

Chemical analyses of water from selected wells and springs [ANALYSES BY U.S. GEOLOGICAL SURVEY. UNDERLINED CONCENTRATION IS IN EXCESS OF THAT RECOMMENDED BY U.S. PUBLIC HEALTH SERVICE (1962) STANDARDS FOR DRINKING WATER. MG/L=MILLIGRAMS PER LITRE; UG/L=MICROGRAMS PER LITRE] SOLVED MAG-NE-SIUM DIS-SOLVED FLUO-RIDE (F) SOLVED NITRITE PLUS NITRATE SOLVED ORTHO PHOS-PHATE (PO4) SOLVED SOLIDS (SUM OF CDNSTI-TUENTS) SOLVEO MAN-GANESE SOL VED CAL-CIUM DIS-SOLVED SULFATE LOCATION SOLVED CHLO-HIOE CON-GEDLOGIC UNIT SOLVED AD-SORP-TION ARSENIC (AS) TEMPER-1 NB03501034BB0 ANIMAS FORMATION ANIMAS FORMATION 2 NB03400618BC 04-15-75 NB03400703DAA 04-15-75 5 NB03400B02BA0 ANIMAS FORMATION NRO3400RORAD 7 NB03400911BC 12-11-74 12-12-74 ANIMAS FORMATION CLIFF HOUSE SANDSTONE 9 NB03401206CD 10 NB03500704CBA 05-11-75 04-15-75 05-11-75 ALLUVIUM ALLUVIUM L1 NB03500726AA 12 NB03500734ABI 13 NB03500807CA 14 NB03500808BCC 15 NB03500819BCD KIRTI AND SHALE NB03500823CC ANIMAS FORMATION 7 NB035009030C 18 NB03500905BCA MORRISON FORMATION 20 NB03500912CAC MANCOS SHALE 21 NB035009170CB MANCOS SHALE CLIFF HOUSE SANDSTONE 22 NB03501015DBI 3 NB03501034CBB 24 NBD35011140DC 25 NB035D1123ACC CLIFF HOUSE FORMATION MENEFEE FORMATION 26 NB0350112BBC 04-13-75 27 NB035012D3ADD MANCOS SHALE 04-09-75 04-09-75 29 NB03501217ABD 04-14-75 04-14-75 04-14-75 31 NB036007130AD CUTLER FORMATION 32 NBD3600720ABC MORRISON FORMATION 34 NB036DD724CBD CUTLER FORMATION 35 NB03600728CBB 36 NB036DD729DCB MANCOS SHALE DAKOTA SANDSTONE 37 NB03600733DBB

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